

Advanced Infrared Astronomy

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Strategy

This task supports the application of infrared heterodyne spectroscopy and other high resolution techniques, as well as infrared arrays to ultra-high resolution studies of molecular constituents of planetary atmospheres. High spectral and spatial resolution measurement and analysis of individual spectral lines permits the retrieval of distributions of atmospheric molecular abundances and temperatures and thus, information on local photochemical processes. Determination of absolute line positions to better than 10^{-8} permits direct measurement of gas velocities to a few m/sec and thus, the study of dynamics. Observations are made from ground based observatories (e.g. NASA Infrared Telescope Facility on Mauna Kea, Hawaii).

Progress and Accomplishments

Jupiter - First measurements of ethylene on Jupiter were analyzed to reveal localized enhancement near the N polar hot spot (180° long., 60° lat.). Single line emission near 10.5 μm indicated a 13-fold increase in C_2H_4 abundance over that in the quiescent regions, or a 115K increase in temperature near 10 μbar . Most of the observed enhancement in line emission was found to originate near 10 μbar . Analysis of simultaneous measurements at 12 μm (ethane) and 2.1 μm (H_2 , H_3^+) by L. Trafton, U. Texas, showed no significant activity in the S polar region in Dec. 1989. An attempt to study the temporal variability and morphology of the stratospheric emission from the principal hydrocarbon constituents (CH_4 , C_2H_2 , C_2H_6) from Jupiter's polar regions was prevented by bad weather at the IRTF. This attempt will be repeated in FY92. *Mars* - Global distribution of ozone in the atmosphere was determined from single line measurements near 9.7 μm . Inversion of simultaneously measured CO_2 line profiles permitted the retrieval of needed temperature profiles. An ozone column burden of $<2.2 \mu\text{m-atm}$ for $\text{Ls} \sim 204$ was retrieved, consistent with results from existing photochemical models. Direct measurements of global winds were made using Doppler shifts of 10 μm CO_2 absorption and emission lines. Data are presently being analyzed. *Venus* - The study of global circulation is continuing with observations of Doppler shifts of mesospheric and thermospheric CO_2 features during opposite phases near Venusian inferior conjunction. Analysis is in progress. Zonal, subsolar-antisolar, and predicted mesospheric return flow will be retrieved from these data.

Projected Accomplishments

We propose to study the temporal variability and morphology of the stratospheric emission from the principal hydrocarbon constituents (CH_4 , C_2H_2 , C_2H_6) from Jupiter's polar regions. The focus will be to image the polar hot spots and auroral regions and determine any correlation with 2-4 μm observations and ultraviolet auroral activity as observed simultaneously with the IUE. The goal is to investigate the energy source for the IR enhancement (e.g. energetic particles) and resultant species distribution around the north polar hot spot, which would be dependent on the changes in local photochemistry and diffusion of the product hydrocarbons in the Jovian stratosphere. The study of Jovian ethylene variability will continue. Observations of global circulation on Venus using the 10 μm CO_2 spectra will continue and will be correlated with mm-wave results. A comprehensive global circulation model will be developed. Ethane abundances on Saturn and Titan will be determined using line spectra measurements. An attempt to measure Titan's global circulation will also be made using the measured C_2H_6 lines.

Publications

- 1990 "Ethane Abundance on Neptune", T. Kostiuk, F. Espenak, P. Romani, D. Zipoy, and J. Goldstein, *Icarus* 88, 87-96.
- 1990 "Miniaturized, 9-12 Micron Heterodyne Spectrometer with Space Qualifiable Design Features", D. A. Glenar, M. J. Mumma, T. Kostiuk, H. Huffman, J. Degnan, H. Dave, U. Hochuli, and P. Haldemann. SPIE Vol. 1235, *Instrumentation in Astronomy VII*, 933-942.
- 1990 "Ground Based Measurements of the Global Distribution of Ozone in the Atmosphere of Mars", F. Espenak, M. J. Mumma, T. Kostiuk, and D. Zipoy. *Icarus* (to be published).
- 1990 "On the Detectability of the Jovian Oscillations with Infrared Heterodyne Measurements", B. Mosser, D. Gautier, and T. Kostiuk (submitted to *Icarus*).
- 1990 "Absolute Wind Velocities in the Lower Thermosphere of Venus Using Infrared Heterodyne Spectroscopy", J. Goldstein, M. J. Mumma, T. Kostiuk, D. Deming, F. Espenak, and D. Zipoy. (submitted to *Icarus*).
- 1990 "A Self-Consistent Picture of Circulation in Venus' Atmosphere from 70 to 200 km Altitude", J. Goldstein, M. J. Mumma, T. Kostiuk, and F. Espanak. (submitted to *Icarus*).